Investigation of Ethanol as a General Aviation Fuel

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1. Introduction

The aviation industry is coming under increasing pressure to remove lead from Aviation Gasoline – the last fuel in the USA with an exemption from the Clean Air Act Amendments banning the use of lead in gasoline. The oil industry has not yet developed a lead-free viable alternative with the requisite octane necessary for many aviation piston engines, especially those with higher performance characteristics. E 95 (denatured ethanol) has been proven as a high octane, viable alternative aviation fuel.

Given the distinct possibility of General Aviation adopting ethanol as its fuel, a logistical problem requires solution – that of an orderly transition over a period from the currently used aviation gasoline to ethanol. Given the likelihood that aircraft could require refueling at locations where either fuel is not supplied during the transition period, it is important to research the effects of flying on various blends of avgas and ethanol. The Renewable Aviation Fuel Development Center (RAFDC) within the Baylor Institute for Air Science at Baylor University has developed considerable expertise over the past two decades over the use of 100% denatured ethanol and all possible blends of ethanol and aviation gasoline in aircraft engines.

The focus of the current FAA research program is to investigate the chemical and technical characteristics of all possible blends of denatured ethanol and aviation gasoline in order to ensure that pilots of all skill levels will be able to operate aircraft safely with engines modified to use ethanol. Flight-testing and test cell work are currently being undertaken to this end, and this paper describes the current progress.

2. Objectives

Six major objectives are included in the scope of work document and these are as follows;

- Collection of baseline data for flight-testing and dynamometer bench testing with both 100 LL avgas and 100% denatured ethanol fuels.

- Testing of binary blends of these two fuels in set ratios using 4 different aircraft, 2 with low compression engines and 2 with high compression ratios, with particular attention paid to leaning techniques. These blends will also be tested on the dynamometer, and the exhaust emissions will be measured for various runs as required.

- Materials compatibility will also be reported for these blends.

- Cold start problems will be investigated

- A number of specific concerns raised by the New England Region Technical Center to do with the fuel systems are to be addressed

- A flight school field study is also part of the SOW, planned for year three of the program.

In addition to these six stated objectives, a new concern regarding detonation in ethanol fueled engines has been raised.. This is contrary to all experiences thus far of the RAFDC at Baylor University, but nonetheless, additional capability in the test cell is being installed to definitively address this problem (if it exists) also.

3. Research Activities, including Achievements

Work on the first five of the objectives plus the detonation issue is proceeding concurrently, with some areas further advanced than others.

Flight tests of the Cessna 172, Pitts Special and Cessna 152 have begun and the Piper Pawnee is being readied for flight. Testing has been carried out to ensure different pilots in the same aircraft get similar results, especially vis-à-vis leaning requirements, and that the same pilot can also operate different aircraft and obtain similar results. This flight-testing is continuing.

Dynamometer work is also in progress collecting baseline data, including runs with exhaust emission data. The ranges required for calibration gases has been determined to refine the accuracy of emission information, especially with regard to aldehyde (both formaldehyde and acetaldehyde) emissions.

The cold start problem seems to have been solved by a method not involving a dual fuel system. This method has been successfully tested in temperatures down to 18° F. During the winter it will be further tested at appropriate locations.

Other issues are being addressed as they arise, including investigations into possible detonation by use of pressure transducers mounted in each cylinder.

4. Anticipated results

It is anticipated that no insurmountable problems will emerge to prevent the use of blends of ethanol and avgas as an interim fuel for general aviation piston engines. This confidence is based on prior testing involving many hours of flight involving fuel blends. Aldehyde emissions have been shown to increase when using alcohol fuels and conditions that minimize these emissions are yet to be investigated to ensure these meet environmental regulations.